The association of taste sensitivity with perception and liking of beer and cider

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Beer flavour (‘taste’) =

Basic tastes + olfaction + chemesthesis

- 6 (ish) basic tastes – **bitter**, **sour**, **sweet**, salt, umami, oleogustus
  - Gustatory system
- Olfaction (smell)
  - Orthonasal vs retronasal
- Chemesthesis (‘tactile’/’somatosensory’/’mouthfeel’)
  - Astringency, **fullness**, heat, cold, **prickling**, irritation/pain
  - Trigeminal system
Success in increasingly competitive enviro requires:

• Segmenting total market
  ➢ identifying unique/poorly described segments
• Strategically adapting marketing tools to the needs of these target segment(s) (Bezawada et al., 2012).

Taste and flavour are key factors affecting beer liking and purchase decisions

➢ An understanding of individual differences in taste of interest to industry: may represent product development & marketing opportunities (Pickering & Cullen ‘08).
Intake (monthly) of alcoholic beverages and responsiveness quantiles for bitterness (n = 435), sourness (n = 435) and astringency (n = 261).
Association (biserial correlation) between taste responsiveness and alcohol drinker status.

Values represent mean intensity ratings on generalized visual analog scales ± SD.

<table>
<thead>
<tr>
<th>Drinker status</th>
<th>Intensity difference</th>
<th>r</th>
<th>p(r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol avoider (n)</td>
<td>Consumer (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweetness</td>
<td>50.6 ± 21.9 (26)</td>
<td>43.2 ± 20.0 (280)</td>
<td>17%</td>
</tr>
<tr>
<td>Sourness</td>
<td>48.9 ± 23.1 (26)</td>
<td>38.7 ± 19.4 (280)</td>
<td>26%</td>
</tr>
<tr>
<td>Bitterness*</td>
<td>56.7 ± 30.1 (12)</td>
<td>43.2 ± 23.2 (108)</td>
<td>31%</td>
</tr>
<tr>
<td>Saltiness</td>
<td>56.8 ± 26.9 (21)</td>
<td>47.8 ± 20.9 (153)</td>
<td>19%</td>
</tr>
<tr>
<td>Umami</td>
<td>55.0 ± 24.6 (26)</td>
<td>49.4 ± 25.9 (280)</td>
<td>–</td>
</tr>
<tr>
<td>Metallic</td>
<td>50.0 ± 26.1 (9)</td>
<td>49.0 ± 33.6 (81)</td>
<td>–</td>
</tr>
<tr>
<td>Astringency</td>
<td>45.5 ± 22.0 (5)</td>
<td>35.9 ± 17.7 (127)</td>
<td>–</td>
</tr>
</tbody>
</table>

Thermal tasters (TT) perceive tastes on heating & cooling the tongue (taste ‘phantoms’) (Cruz & Green, ’00)

- 20-50% of the population are TTs

Thermal tasters perceive some tastes more intensely than do thermal non-tasters (TnT) (Green et al. 2004; Bajec & Pickering, ’08, Yang et al. ‘14)

- may extend to (some) foods & beverages

TRPM5 & other temp-sensitive receptors/channels (Talavera et al., ‘05) & cross-wiring of gustatory & trigeminal receptors (Hort et al. ‘16) may be involved
Thermal taster status and intensity ratings of oral sensations elicited by beer

Hoegaarden (wheat beer)  Molson Canadian (lager)

Headstrong Pale Ale  Pickering et al. (2010), *J Inst Brewing, 116(3), 239.*
1. Does perception of the oral sensations elicited by beer and cider vary with thermal taste status?

2. To what extent does responsiveness to beer/cider-relevant tastants associate with responsiveness to beer & cider?
   - Do thermal tasters experience beer/cider-relevant tastants more intensely than non-tasters?

3. Do (1) or (2) associate with liking/preference for beer/cider?
   - Liking as proxy for consumption
Methodology

• Participants: 60 volunteers from Brock Uni & community completed study
  – 21 females; 23.2 years ± 5.9; 62% Caucasian, 12% Chinese, 26% Other
  – TTS per Bajec & Pickering (2008): 31 TT (9 male) & 29 TnT (12 male)

• The study was conducted over 3 sessions
  
  • Session 1: Basic taste training, gLMS and gVAS familiarization, TTS determination, completion of surveys (incl. health, demographic information).
  
  • Session 2: Rating intensity of key components impacting beer/cider flavour: ethanol, citric acid, d-glucose and iso-α-acids.
  
  • Session 3: Rating of intensity and hedonics of sampled beer & cider.
Methodology - Session 1

Determination of Thermal Taster Status (Bajec & Pickering, 2008)

Source: Martha R. Bajec
Methodology - Session 2

• Determination of taste responsiveness to components of beer eliciting sweet, sour, bitter & irritation

- 20 ml aqueous solutions of:
  - Iso-α-acids (10, 20, 50 mg/L)
  - Ethanol (2, 4, 5, 7, 10 % v/v)
  - Citric acid (56, 230, 550 mg/L)
  - Dextrose (7, 40, 80 g/L)

• Samples presented using Williams Latin Square Design; data collected using computer software - Compusense 5
### Beer- and cider-relevant tastants and oral sensations assessed

<table>
<thead>
<tr>
<th>Component</th>
<th>Oral sensations</th>
<th>Concentration</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextrose</td>
<td>Sweetness</td>
<td>7, 40, 80</td>
<td>g/L</td>
</tr>
<tr>
<td>Citric acid</td>
<td>Soursness</td>
<td>56, 230, 550</td>
<td>mg/L</td>
</tr>
<tr>
<td>Iso-α-acid</td>
<td>Bitterness</td>
<td>10, 20, 50</td>
<td>ppm</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Bitterness, Sweetness, Irritation/burning</td>
<td>2, 4, 5, 7, 10</td>
<td>%v/v</td>
</tr>
</tbody>
</table>
Beer/cider evaluation. 8 samples (6 °C):

Beer: Same base beer
- Alcohol varied: 5, 7, 10% v/v
- Iso-α-acid conc varied: 10, 25, 50 ppm

Cider: 0, 25 ppm iso-α-acid

- 9-point hedonic scale (1-dislike extremely to 9-like extremely)
- Intensity rating of sensations (sweet, sour, bitter, astringent/drying, carbonation, warming, overall taste intensity)
Generalized line scale (gLS) used for collecting intensity responses to beer.
Thermal taste status and intensity ratings (± SE) of beer-relevant tastants (averaged across multiple concentrations; TT = 31, TnT = 29)
Thermal taste status and intensity ratings (± SE) of ethanol (averaged across 5 concentrations; TT = 31, TnT = 29)

Thermal taste status and intensity ratings (± SE) of ethanol (averaged across 5 concentrations; TT = 31, TnT = 29)
TTS and beer-relevant tastants responses

![Graph showing the relationship between mean log intensity ratings and ethanol concentration. The graph includes two lines, one for TnT (blue) and one for TT (red). The equation for TnT is y = 0.1495x + 0.560 with R² = 0.877. The equation for TT is y = 0.0835x + 0.632 with R² = 0.675.](image-url)
Thermal Taste Status & sampled beer/cider flavour

Mean log intensity ratings

- Sweetness
- Sourness
- Bitterness
- Astringent/Drying
- Carbonation/Prickling
- Warming
- Overall Taste Intensity

TnT
TT
F-values from analysis of covariance of beer/cider liking scores

<table>
<thead>
<tr>
<th>Sample treatment</th>
<th>Age</th>
<th>Sex</th>
<th>TTS</th>
<th>Significant interactions (F-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low alcohol beer</td>
<td>0.2</td>
<td>0.1</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Medium alcohol beer</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>High alcohol beer</td>
<td>0.06</td>
<td>1.3</td>
<td>6.6*</td>
<td>Age<em>TTS (7.1</em>)</td>
</tr>
<tr>
<td>Low hopped beer</td>
<td>0.1</td>
<td>0.5</td>
<td>1.6</td>
<td>-</td>
</tr>
<tr>
<td>Medium hopped beer</td>
<td>2.7</td>
<td>0.1</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>High hopped beer</td>
<td>0.8</td>
<td>1.7</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>Cider</td>
<td>4.8</td>
<td>0</td>
<td>4.3*</td>
<td>-</td>
</tr>
<tr>
<td>Hopped cider</td>
<td>7.9</td>
<td>0.1</td>
<td>1.5</td>
<td>Sex<em>TTS (4.3</em>)</td>
</tr>
</tbody>
</table>
Sex x Thermal Taste Status for liking of hoped cider

[Diagram showing the relationship between sex and thermal taste status for liking of hoped cider with error bars for each group.]

9-point hedonic score

Female          Male

TTS-TT

TTS-TnT
Importance of specific factors in beer purchase decision  
(1-Not important, 7-Extremely important; n=60)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean of ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>7.171</td>
</tr>
<tr>
<td>Style</td>
<td>5.357</td>
</tr>
<tr>
<td>Occasion</td>
<td>4.929</td>
</tr>
<tr>
<td>Price</td>
<td>4.800</td>
</tr>
<tr>
<td>Size</td>
<td>4.057</td>
</tr>
<tr>
<td>Brand</td>
<td>3.829</td>
</tr>
<tr>
<td>Other</td>
<td>2.943</td>
</tr>
<tr>
<td>Label</td>
<td>2.914</td>
</tr>
</tbody>
</table>

**Thermal tasters**  
(Q=87.9, p<0.0001)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean of ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>6.278</td>
</tr>
<tr>
<td>Price</td>
<td>5.694</td>
</tr>
<tr>
<td>Occasion</td>
<td>5.278</td>
</tr>
<tr>
<td>Style</td>
<td>4.917</td>
</tr>
<tr>
<td>Size</td>
<td>4.111</td>
</tr>
<tr>
<td>Brand</td>
<td>3.528</td>
</tr>
<tr>
<td>Label</td>
<td>3.222</td>
</tr>
<tr>
<td>Other</td>
<td>2.972</td>
</tr>
</tbody>
</table>

**Thermal non tasters**  
(Q=40.1, p<0.0001)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean of ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>6.278</td>
</tr>
<tr>
<td>Price</td>
<td>5.694</td>
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<tr>
<td>Occasion</td>
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<td>Label</td>
<td>3.222</td>
</tr>
<tr>
<td>Other</td>
<td>2.972</td>
</tr>
</tbody>
</table>

- t-test:  
  Taste  
  (t=2.72,  
  p=0.009)
Conclusions

• Thermal tasters (TT) experience the bitterness of ethanol more intensely than non-tasters
  • No difference for dextrose sweetness, citric acid sourness or isohumulone bitterness
• TT rate the sourness, bitterness, astringent/drying and overall intensity of sampled beers and ciders higher
  • Sensitivity to the bitterness of ethanol (not hops) responsible for greater beer & cider bitterness
• Liking of high alcohol beer and cider varies with TTS
• TTs ascribe greater importance to taste when purchasing beer
• 3 clusters identified (this cohort) based on beer/cider liking (bitter dislikers, beer likers, alcohol lovers) that differ in TTS and some demographic characteristics
  ➢ Product optimization and market segmentation opportunities based on taste sensitivity?
Cluster analysis: Agglomerative hierarchical and k-means. 9-point hedonic scores of each cluster

<table>
<thead>
<tr>
<th></th>
<th>Cluster 1 &quot;Bitter dislikers&quot;</th>
<th>Cluster 2 &quot;Beer likers&quot;</th>
<th>Cluster 3 &quot;Alcohol lovers&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low hopped beer</td>
<td>4.2</td>
<td>5.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Medium hopped beer</td>
<td>3.6</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>High hopped beer</td>
<td>2.7</td>
<td>5.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Low alcohol beer</td>
<td>4.4</td>
<td>5.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Medium alcohol beer</td>
<td>4.1</td>
<td>5.9</td>
<td>6.3</td>
</tr>
<tr>
<td>High alcohol beer</td>
<td>3.7</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Cider</td>
<td>4.6</td>
<td>4.0</td>
<td>5.9</td>
</tr>
<tr>
<td>Hoped cider</td>
<td>3.8</td>
<td>4.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>
• **Similar findings with wine** (Pickering et al., 2010 *Australian J. Grape Wine Res.*, 16, 361–367).

• **Do differences extend to beer liking & consumption?**
  – Sample size too small here
  – Unpublished data suggests TnTs like all alc. beverages more than TTs (Bajec & Pickering, 2014 *in prep*)

• **So what?**
  • Product development/optimisation
  • Marketing ....
Conclusions

• Thermal tasters appear to possess a global ‘advantage’ in perception of beer flavour intensity
  • this may extend to greater acuity/discrimination (data not shown)

• Both thermal & PROP-tasting phenotypes link with beer liking & probably preference & consumption

• Beer marketing tools can ? exploit this through
  • targeted advertising
  • utilizing differences in emotional reactivity
  • others ?

• Challenges:
  • how to identify & target these taste segments
    ➢ self-identify (www.supertasting.com)

• Opportunities for industry collaboration
Exploit behavioral or psychological factors that co-vary with taste sensitivity

Emotional reactivity & PROP tasting

- Heightened taste sensitivity (STs) may correspond with heightened emotional arousal, at least for anger (Macht & Mueller 07)

- Super-tasters more responsive to emotional disgust than medium- and non-tasters (Herz ‘11)

If extends to other emotions ... represents avenue for connecting taste phenotype through emotionally-coded advertisements, promotions and possibly branding
Exploit taste sensitivity

Differences between taste phenotypes in the intensity of the sensations elicited by beer may be directly exploited through advertising/promotion.
TTS and self-reported beer/cider consumption

Mann-U Whitney found no significant differences between TT and TnT

- TTS and beer monthly consumption
  - U=1.229, p=0.219
- TTS and beer consumption frequency
  - U=1.582, p=0.114
- TTS and beer drinks per occasion
  - U=0.851, p=0.395

- TTS and cider monthly consumption
  - U=0.702, p=0.482
- TTS and beer consumption frequency
  - U=1.428, p=0.153
- TTS and beer drinks per occasion
  - U=0.000, p=0.615

- Did not meet assumptions
No harsh bitterness
Just the KISS of the hops

America's Most Distinguished Beer

THE BEER THAT MADE MILWAUKEE FAMOUS
The most studied taste phenotype is PROP ...
PROP taster phenotype

• 6-n-propylthiouracil (PROP)
  ➢ Different bitterness response
  ➢ Super-Tasters > Medium-Tasters > Non-Tasters

• Proxy for general taste responsiveness
  (Gent & Bartoshuk, ’83; Bartoshuk et al., ’98; Prescott et al., ’01; Karrer et al., ’91; Bartoshuk et al., ’93; Prescott & Swain-Campbell, ’00; Tepper & Nurse, ’97; Essick et al., ’03).

• Genetics & physiology
  - TAS2R38 gene (AVI/AVI, PAV/AVI, PAV/PAV)
  + other genes (Duffy et al., ’04; Hayes et al., ’08; Bering, ’10)

  - Fungiform papillae density
    (Reedy et al., ’93; Bartoshuk et al., ’94; Tepper & Nurse, ’97; Essick et al., ’03; Hayes et al., ’08)
Your PROP-tasting phenotype matters for beer perception/behaviour

• Highly PROP responsive individuals rate the bitterness of some beer higher than less responsive individuals (Intranuovo & Powers, 1998; Lanier et al., 2005)

• May translate into consumption behaviour:
  • pSTs consume less beer when they first started drinking compared to pNTs (Intranuovo & Powers, 1998)
  • high-consumption group: more pNTs, less pSTs (Guinard et al., 1996)
Thermal Taste Status & beer/cider liking

NS – Not Significant, p>0.05